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Anti-spoofing in Face Recognition Systems based on Projective Invariants and Stereo Recording

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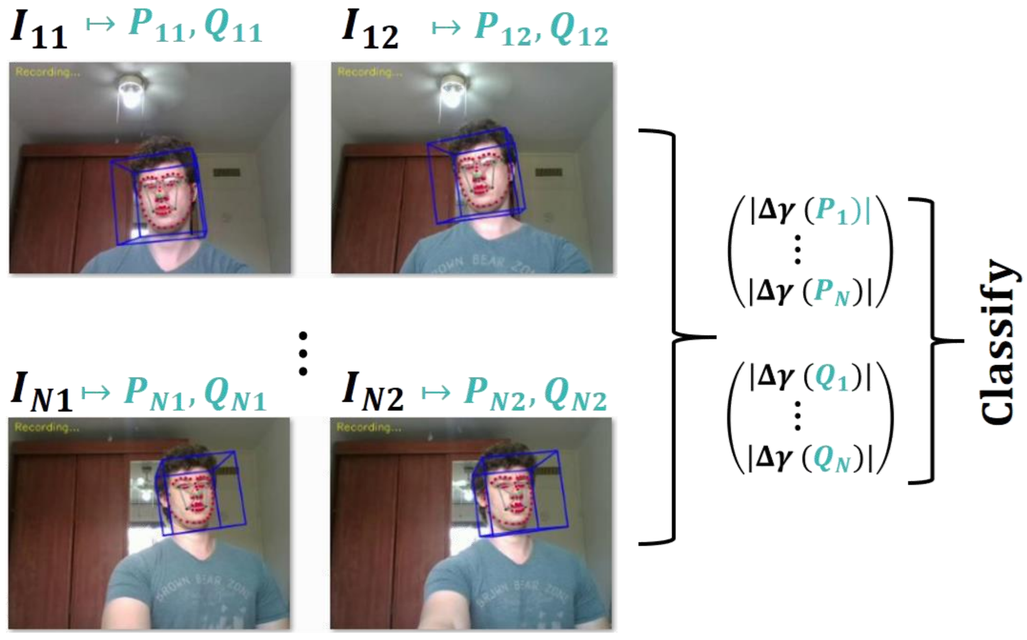
Introduction

- **Problem**: How to detect a spoofing attack in authentication systems based on automatic face recognition.

Authorized person **Print attack** **Video attack**

- **Model-based solutions:** Semi-automatic, unreliable.
- **Deep learning solutions:** Require large datasets, generalize poorly.
- **Our hybrid approach:** Automatic**,** inexpensive**,** do not require large datasets, works in indoor and outdoor settings.

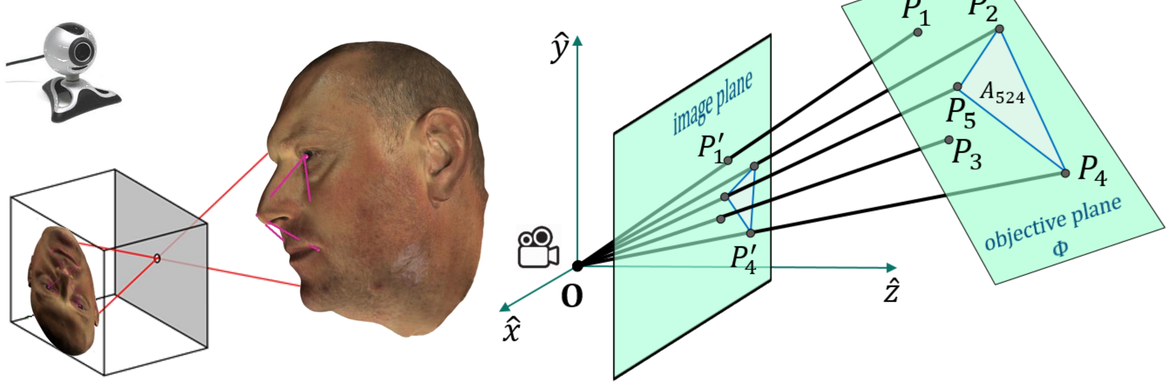
Dataflow



$(0, \delta_1 \sum \Delta\gamma(Q_i))$ spoofed $(\delta_2 \sum \Delta\gamma(Q_i), \infty)$ genuine

Projective invariants

- **Pinhole camera model**



- **Five point cross-ratio**

3D points: $\gamma(P_1, P_2, \dots, P_5) = \dfrac{A_{514}A_{523}}{A_{513}A_{524}}$

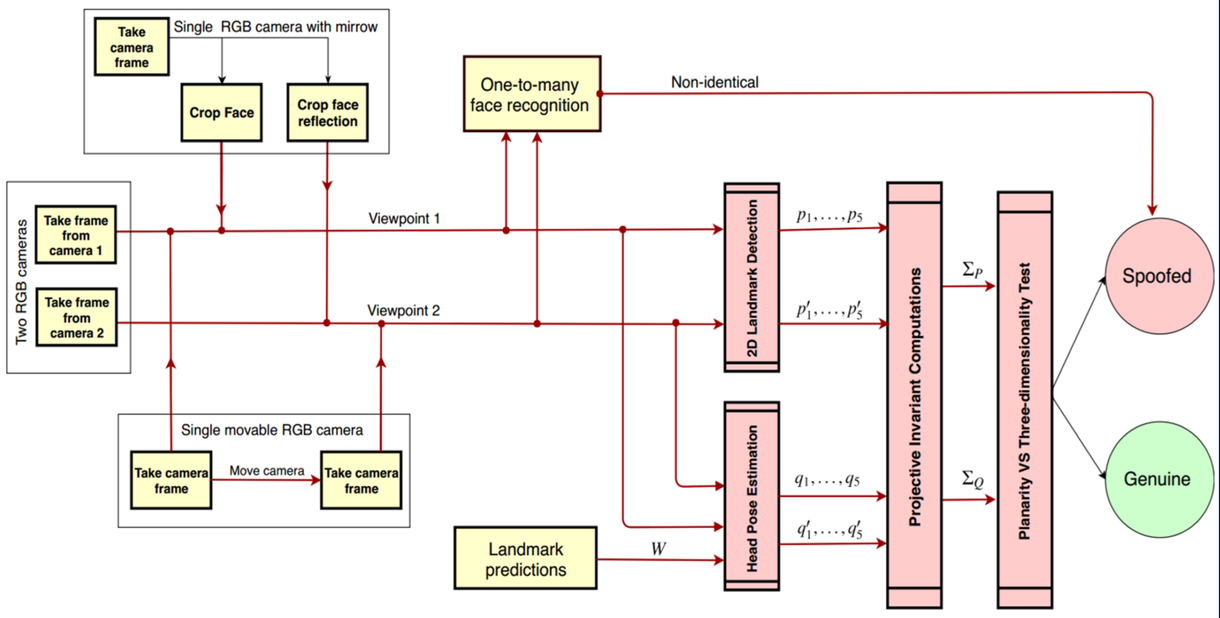
2D points: $\gamma(P'_1, P'_2, \dots, P'_5) = \dfrac{A'_{514}\,A'_{523}}{A'_{513}A'_{524}}$

A_{ijk} = area of $\Delta(P_i, P_j, P_k)$

- **Five point projective invariants**

$$\gamma(P_1, P_2, \dots, P_5) = \gamma(P'_1, P'_2, \dots, P'_5)$$

Generalized algorithm

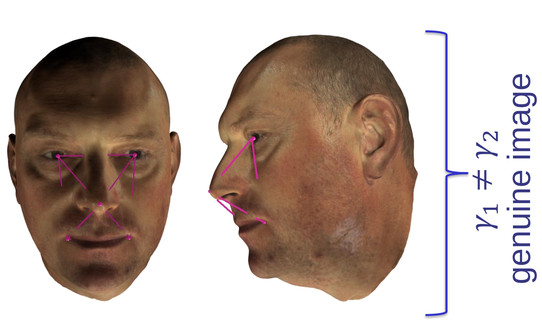


Future work

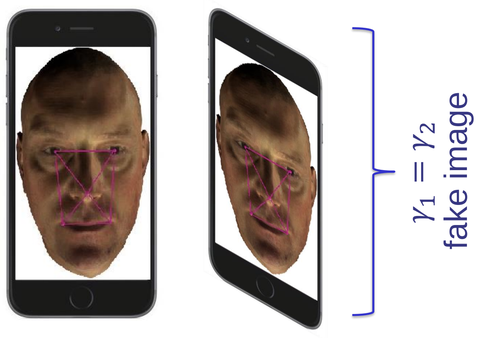
- **Single movable camera**
- **Better landmark detector**
- **3D face reconstruction**
- **Several subsets of facial landmarks**
- **More parameters for the model**

Five point invariants for anti-spoofing

- **Stereo recording with projective invariants**
  1. Select 5 non-coplanar facial landmarks $\{x_i(t), y_i(t)\}_{i=1}^{5}$
  2. Measure cross-ratios $\gamma_1(t)$ and $\gamma_2(t)$ from two cameras
  3. Compare $\gamma_1(t)$ and $\gamma_2(t)$ using per-frame calibration



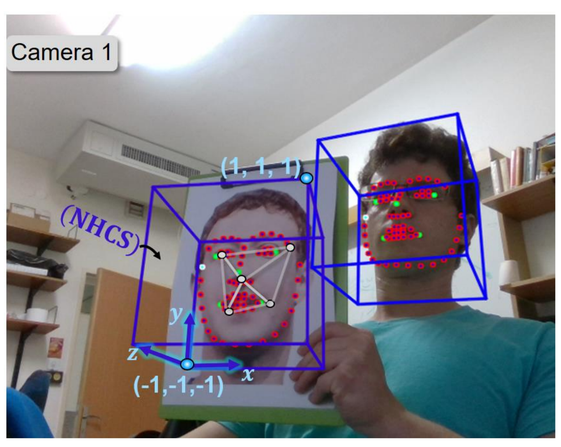
$\gamma_1 \neq \gamma_2$ genuine image

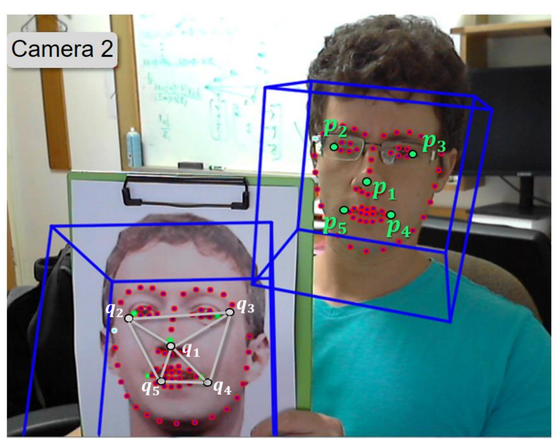


$\gamma_1 = \gamma_2$ fake image

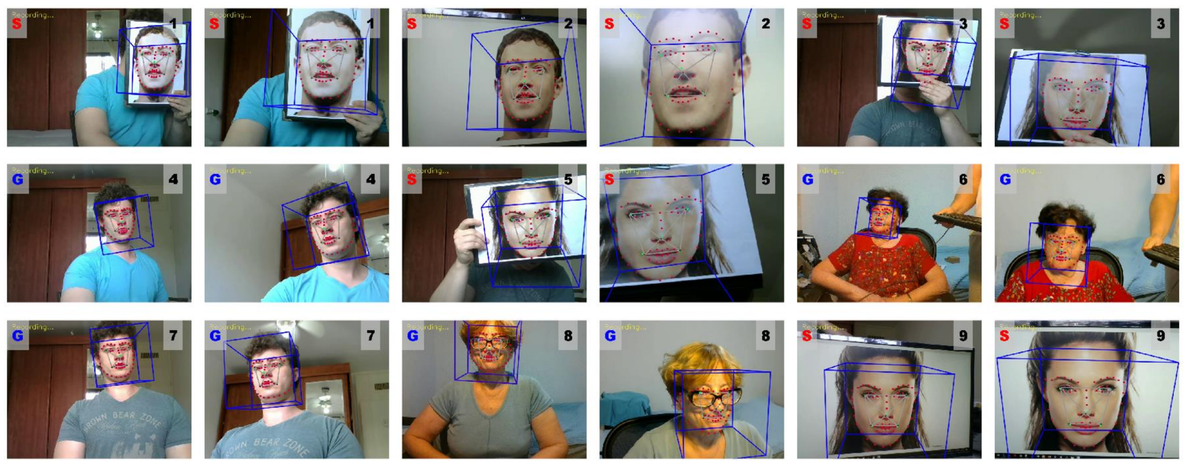
- **Per-frame calibration**
  1. Predict landmark positions of the mean face using NHCS
  2. Compare predictions with cross-ratio differences

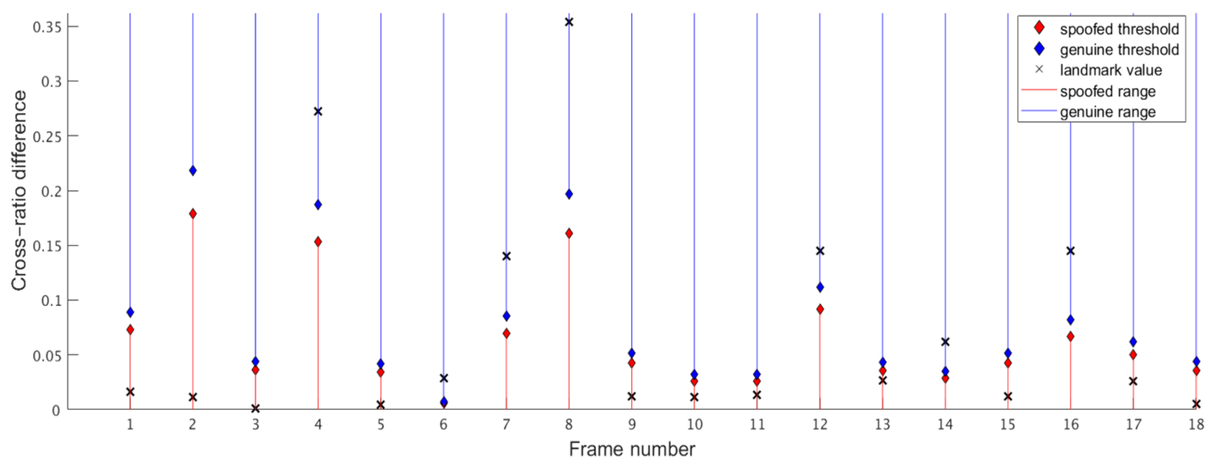
$$\left|\gamma_1^{\text{spoofed}} - \gamma_2^{\text{spoofed}}\right| < \varepsilon\Delta q, \qquad \left|\gamma_1^{\text{real}} - \gamma_2^{\text{real}}\right| > r\Delta q$$





Results





References

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